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 Washington D.C., 20231

Case Docket No.: 81674-265759

Date: June 27, 2000

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Dear Sir:

Transmitted herewith for filing is the patent application of
 Inventor(s): David L. GRAUMANN of Beaverton, Oregon
 For: ENHANCED ACOUSTIC TRANSMISSION SYSTEM AND METHOD

Enclosed are:

- ☒ 5 Sheets of formal drawings
☒ An assignment of the invention to Intel Corporation.
☒ Declaration and Power of Attorney.

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ITEM	NO. OF CLAIMS FILED MINUS BASE*	NO. OF CLAIMS OVER BASE	X SM/LG ENTITY FEE	\$ AMOUNT	FEE
A TOTAL CLAIMS FEE	29 -20*=	9	x \$9 or x \$18	\$ 162	
B INDEPENDENT CLAIMS FEE**	6 - 3*=	3	x\$39 or x 78	\$234	
C SUBTOTAL - ADDITIONAL CLAIMS FEE (ADD FINAL COLUMN IN LINES A + B)					\$396
D MULTIPLE-DEPENDENT CLAIMS FEE			SMALL ENTITY FEE = \$130 LARGE ENTITY FEE = \$260		\$0
E BASIC FEE*			SMALL ENTITY FEE = \$345 LARGE ENTITY FEE = \$690		\$690
F TOTAL FILING FEE (ADD TOTALS FOR LINES C, D, AND E)					\$1086
G ASSIGNMENT RECORDING FEE				\$40	\$40
**LIST INDEPENDENT CLAIMS 1, 7, 9, 18, 21 and 25					

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James R. Wise

PILLSBURY MADISON & SUTRO LLP
725 South Figueroa Street, Suite 1200
Los Angeles, CA 90017-5443
Telephone: (213) 488-7100
Facsimile: (213) 629-1033

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PATENT
81674-265759

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
David L. GRAUMANN
Serial No.: NOT ASSIGNED
Filed: June 27, 2000
For: ENHANCED ACOUSTIC TRANSMISSION
SYSTEM AND METHOD

Group No.: NOT ASSIGNED

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**APPLICATION FOR
UNITED STATES PATENT
IN THE NAME OF**

DAVID GRAUMANN

FOR

ENHANCED ACOUSTIC TRANSMISSION SYSTEM AND METHOD

Prepared By:

PILLSBURY MADISON & SUTRO LLP

**Ninth Floor, East Tower
1100 New York Avenue, N.W.
Washington, D.C. 20005-3918
Telephone (213) 488-7100
Facsimile (213) 629-1033**

Attorney Docket No: 81674-265759

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TITLE OF THE INVENTION

ENHANCED ACOUSTIC TRANSMISSION SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

The present invention relates to a system and method for generating an enhanced acoustic transmission signal for a psychoacoustically-motivated auditory band communication channel carrying data and audio signals.

10 2. Discussion of the Related Art

When exploring the psychology of hearing as a means to improved human computer interfaces, it becomes apparent that there are vast differences between the human auditory system and acoustical transducers used by computers. Though both convert sound pressure waves into energy differentials, the resultant signals do not have similar spectral content. A transducer, (e.g., a microphone) often has a near-flat frequency response that is not tuned to human speech. It converts all frequencies into appropriate voltage levels that are limited only by its sensitivity and dynamic range. If digitally sampled for computer enhancement, the frequency response is additionally determined by the Nyquist frequency. In the digital domain, there exists many methods for extracting all of the frequencies present in the signal whether or not they are
15
20 audible by human ears. A very different signal is made available through the auditory system for human cognition. For the human percept, there are many preprocessing mechanisms that limit access to the frequencies in the environment. These preprocessing mechanisms include the natural resonance of the ear canal, the time-varying non-linear transfer function of the middle

ear, and the complex conversion of mechanical pressures to electrochemical firings taking place in the cochlea. The physics of this complex conversion process is quite remarkable — sound energy is converted into mechanical motion, which is converted back to sound energy, then converted back into mechanical motion, which is detected and converted into electrochemical
5 nerve signals. These processes selectively enhance perception of human speech and important localization phenomenon, as opposed to simply converting sound pressure into neuron firings. The human auditory system distinguishes sounds on the basis of duration, direction, pitch, loudness, and timbre.

Psychoacoustic masking has been used in digital speech processing over the last 10 years. There also exists masking techniques used in the encoding of audio signals to best avoid
10 perceptual encoding noises. Additionally, there are masking techniques used in some acoustic noise reduction schemes for reducing the aggressiveness of the reduction. However, there are currently no viable psychoacoustic masking applications for use in in-band communication channels for creating enhanced acoustic transmission signals that are compatible with legacy
15 analog communication systems, such as conventional telephones.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a system for generating a masked encoded signal according to an embodiment of the present invention;

20 Fig. 2 illustrates a system for generating an audio signal according to an embodiment of the present invention;

Fig. 3 illustrates the components of an enhanced telephone transmission signal in the frequency domain according to an embodiment of the present invention;

Fig. 4 illustrates a system for generating an enhanced acoustic transmission signal according to an embodiment of the present invention; and

Fig. 5 illustrates a decoding device for decoding an enhanced acoustic transmission signal according to an embodiment of the present invention.

5

DETAILED DESCRIPTION

According to an embodiment of the present invention, an enhanced acoustic transmission signal seeks to exploit a discrepancy between “computer listening” and “human listening” by leveraging auditory simultaneous masking. Simultaneous masking refers to the phenomenon in which one signal being presented to the ear limits the ability for some set of other signals to be audible. The masked signals become imperceivable, or nearly so. An embodiment of the present invention utilizes a masking signal, such as a narrowband stationary noise signal, to mask a carrier signal, which may be an adjacent pure tone signal. The masking takes place in the cochlea of the human ear. By stimulating the basilar membrane with random noise or a bandwidth less than one critical band of the carrier signal, one’s ability to distinguish the carrier signal, and particularly pure tones, within the critical band becomes greatly diminished.

In the human ear, each band of frequencies is centered around a frequency where the response of a given nerve is most sensitive (more specifically, the frequency that takes the smallest signal to trigger the nerve to fire). The width of the band around this central frequency is called the critical bandwidth (or critical band). Therefore, two sounds with close frequencies, within the critical bandwidth will both cause the same nerve cells to fire.

The present invention includes a system for generating a masked encoded signal within an enhanced acoustic transmission signal. The enhanced acoustic transmission signal may be

generated by a communications device, such as a telephone handset having an encoder or a computer having telephony support (such as Internet Protocol (IP) telephony), adapted to generate and encode enhanced acoustic transmission signals for transmission to another communications device. The other communication device may be a decoding handset that can
5 decode and utilize the data being transmitted, or it may be a legacy analog handset that can output the audio portion of the enhanced acoustic transmission signal.

The enhanced acoustic transmission signal (the composite signal 100 as illustrated in Fig. 4) includes the masked encoded signal 180 and the audio signal 190. Referring to Fig. 1, the masked encoded signal 180 includes a modulated carrier signal 160 and a masking signal 170. Data 110 to be transmitted with the audio signal 190 is transmitted to a data signal generator 120,
10 which converts the data 110 into a data signal 130. The data 110 may be any data, and may be used to enhance the telephony experience, such as data for formant expansion into wide-band audio for enriching speech quality, personal/business information (such as mailing addresses, telephone and facsimile numbers, e-mail and Internet addresses, business hours, etc.), simple text
15 messaging for instant information synchronization, enhanced conversation logging by sharing tracking information, or even replacement of dual-tone multi-frequency (DTMF) in-band signaling.

The data signal generator 120 may be a computer, or other device (such as a document scanner, or a business card scanner), used to input or receive data. The data signal generator 120
20 may have a data storage device to store the data, such as a hard disk drive, optical drive (CD-ROM, DVD, etc.), floppy disk drive to receive floppy disks, or even a keyboard for the user to input data to be transmitted. Other devices may be used to input or receive data and convert the data 110 into a data signal 130. The data signal 130 may be of any format that is capable of

representing the data 110. For example, the data signal 130 may be a series of 16 kHz digital
signal pulses representing the data 110 in a sequence having a coded format, such as Morse Code
(in the form of dots, dashes, and pauses). If the data 110 in the data signal 130 is represented by
the length and order of regularly recurring pulses, as in the case of Morse Code, then pulse-
5 duration modulation (PDM) may be performed on the carrier signal 140, as further discussed
below. However, any suitable technique for representing the data 110 in the data signal 130 may
be utilized. Additionally, any suitable modulation technique may be performed on the carrier
signal 140 using the data signal 130.

The selection of the carrier signal 140 is one of the parameters used to generate the
10 masked encoded signal 180. A carrier signal generator 122 generates a carrier signal 140 for
carrying the data 110 within the data signal 130. The carrier signal 140 is preferably a signal that
is capable of being masked by a masking signal 170 generated by a masking signal generator
124. The carrier signal 140 may be, for example, a pure tone sine wave.

The frequency of the carrier signal 140 to be used depends on the application of the
15 enhanced acoustic transmission signal 100. For example, because the frequency of current
“plain old telephone system” (POTS) telephony ranges only from 300 Hz to 3.8 kHz, the carrier
frequency 140 must be at a frequency within the 300 Hz to 3.8 kHz range if the transmission
signal 100 is to be used in conventional POTS systems. However, if a wide-band audio channel
is utilized (such as one having 16 kHz samples per second), a higher carrier frequency may be
20 used, such as a 7 kHz carrier frequency. If a wide-band audio channel is available, the 7kHz
carrier frequency is a good choice because at 7 kHz, the carrier frequency resides in a range in
which there is far less speech energy, and human equal loudness contours show a marked
decrease in absolute signal sensitivity at frequencies of about 5 kHz and greater.

The data signal 130 and the carrier signal 140 are transmitted to a signal modulator 150, which combines the two signals to produce a modulated carrier signal 160. The carrier signal 140 is modulated with the data signal 130 to produce the modulated carrier signal 160. As discussed above, the carrier signal 140 may be, for example, a pure tone sine wave. If, for example, pulse-duration modulation (PDM) is performed on the pure tone sine wave carrier signal 140 using the data signal 130 (wherein the data 110 is represented by the length and order of regularly recurring pulses in a sequence of the data signal 130), the resulting modulated carrier signal 160 would be a pulsed pure tone sine wave. The modulated carrier signal 160 is the original carrier signal 140 modulated with the data signal 130 so as to “carry” the data signal 130. Of course, other modulation techniques may be implemented as well, such as amplitude modulation (AM), frequency modulation (FM), pulse-code modulation (PCM), etc.

The masking signal 170 is generated by a masking signal generator 124. The masking signal generator 124 may be any device capable of generating a masking signal 170 (e.g., noise) having a bandwidth less than one critical band of the modulated carrier signal 160. The masking signal 170 is used to mask the modulated carrier signal 160 from being audible by a human ear. The masking signal 170 is preferably a narrowband random noise sequence. However, other masking signals may be utilized as well. For example, it is known that at 7 kHz, the critical band is approximately 800 Hz. Therefore, a masking signal 170 between 6.6 kHz and 7.4 kHz would fall within the critical band of the modulated carrier signal 160. A masking signal 170 at a frequency of 6.6kHz may be chosen in this example, because it falls within the critical band of the modulated carrier signal 160 frequency and allows for good separation of the masking signal 170 and the modulated carrier signal 160 by using a narrowband filter. At 6.6 kHz, the masking signal 170 allows for a modest finite impulse response (FIR) filter to isolate the modulated

carrier signal 160 without significant out-of-band noise leakage, while still keeping the masking signal 170 within the 800 Hz critical band around the 7 kHz carrier.

The “acceptable” signal strength of the masking signal 170 is a factor in determining the signal strength of the modulated carrier signal 160. In other words, the determination of the masking signal 170 signal strength is, “How loud can the masking noise be without being objectionable to the listener?” The perceptual characteristics of loudness adaptation by the human ear is a factor to consider. There is evidence that low-level steady sounds are perceived with less loudness after continual exposure. More specifically, tones at levels below 30 decibels (dBs) sound pressure level (SPL) audibly vanish for some people after exposure over one minute. (Brian Moore, “An Introduction to the Psychology of Hearing”, Academic Press, IV Ed., 1997, pp. 77-78.) It was found that a random noise masking signal 170 having a bandwidth of 90 Hz and a level of 30 dB SPL is acceptable for use as a masking signal 170 having a center frequency of 6.6 kHz as discussed above. However, broader bandwidths and lower level masking signals 170 may be utilized as well, especially when considering the use of narrowband communication channels where the threshold of hearing drops considerably. Because loudness adaptation varies from person to person, perfect masking may not occur for each individual.

For the most part, the masking signal 170 to be utilized should substantially mask the (modulated) carrier signal 160 from being audible by the human ear. The loudness of the masking signal 170 is preferably of low enough loudness to be acceptable to a user while masking as much of the modulated carrier signal 160 as possible. The final values determined for the masking signal 170 and the modulated carrier signal 160 may simply be a compromise to obtain the best results in all given situations. Once the modulated carrier signal 160 and the

masking signal 170 have been generated, they are combined to form the masked encoded signal 180.

Fig. 2 illustrates a system for generating an audio signal according to an embodiment of the present invention. An audio signal generator 210, receives audio 200, such as voice, music, etc. (from a microphone, telephone handset, a storage medium such as a cassette tape player, CD/CD-ROM, hard disk drive, DVD, tapeless player, etc.), and generates an audio signal 190 for transmission to a receiving device. The audio signal 190 is then passed through a notch filter 220. The audio signal 190 is preferably “notched” so that a relatively narrow band of frequencies surrounding the frequency of the modulated carrier signal 160 is removed from the audio signal 190. The notch 195 (or “dead air” band) helps avoid adverse affects the audio signal 190 may have upon the modulated carrier signal 160. Notching the audio signal helps to better retain the integrity of the data within the modulated carrier signal. Once the enhanced acoustic transmission signal is generated, it may be transmitted to a receiver or decoding device, such as a computer system having telephony support, a decoding handset capable of reproducing audio as well as utilizing the data transmitted along with the audio signal, or even to a legacy handset (conventional telephone) without support for the data extraction features of a decoding handset or computer system.

Fig. 3 illustrates the components of an enhanced telephone transmission signal in the frequency domain according to an embodiment of the present invention. As shown, the audio signal 190 has a notch 195 wherein a narrow band of frequencies surrounding the modulated carrier signal 160 is removed. The audio signal 190 is combined with the modulated carrier signal 160 and the masking signal 170 to form the enhanced acoustic transmission signal 100 (see Fig. 4). In the example shown in Fig. 3, the modulated carrier signal 160 frequency is at the

upper-end of the frequency spectrum. The masking signal 170 frequency is close in frequency to the modulated carrier signal 160. The masking signal 170 having a bandwidth less than one critical band of the modulated carrier signal 160. By having a bandwidth within one critical band of the modulated carrier signal 160, the masking signal 170 preferably masks the
5 modulated carrier signal 160 from being audible by a human ear.

Fig. 4 illustrates a system for generating an enhanced acoustic transmission signal according to an embodiment of the present invention. The masked encoded signal 180 (as illustrated in Fig. 1) may be combined with the notched audio signal 190 by a signal adder to form the enhanced acoustic transmission signal 100. The modulated carrier signal 160 and the
10 masking signal 170 need not be combined prior to being combined with the audio signal 190. Rather, the modulated carrier signal 160, the masking signal 170, and the audio signal 190 may be combined simultaneously by a signal adder 400, or in any other order, to form the enhanced acoustic transmission signal 100.

The motivation for placing a masked encoded signal 180 in the notch 195 of the audio
15 signal 190 is not readily apparent. The main advantage of sending this signal is to enhance the computer telephony experience, while still allowing full unaltered communication with legacy handsets. A decoding handset can detect and utilize the enhanced acoustic transmission signals even over public switched telephone networks (PSTNs) to enhance the audio in a number of ways. On the other hand, if an encoding handset connects to a legacy telephone, or a non-
20 proprietary telephony system not capable of handling the encoding scheme, the encoded signal will not be noticeable by the listener because it is masked, yet it will retain the former audio capabilities of all other non-decoding telephones.

If the receiver is a legacy or non-proprietary handset, such as a conventional analog telephone, the audio portion of the enhanced acoustic transmission signal 100 may be perceived by the listener, while the data within the modulated carrier signal 160 is masked by the masking signal 170 noise so as to be imperceptible by the listener on the legacy or non-proprietary handset. As noted above, perfect masking may not occur (e.g., the listener may hear an occasional “beeping” sound from the modulated carrier signal 170). The masking signal 170 may be initially perceptible to the listener as well. However, due to human loudness adaptation, most listeners will cease to notice the noise from the masking signal after continued exposure.

Fig. 5 illustrates a decoding device for decoding an enhanced acoustic transmission signal according to an embodiment of the present invention. If the receiver is a decoding device, the enhanced acoustic transmission signal 100 is filtered by an audio/masked encoded signal filter 500 of the decoding device to isolate the masked encoded signal 180 from the audio signal 190. The audio signal 190 may be sent to a reproduction device, such as a speaker, or it may be stored on a storage device, such as a cassette tape recorder, hard disk drive, optical drive (CD/CD-ROM, DVD), etc. The modulated carrier signal 160 may be separated from the masked encoded signal 180 by using a filter 510, such as a narrowband finite impulse response (FIR) filter, and then passed to a demodulator 520 to demodulate the modulated carrier signal 160 to extract the data signal 130. Additionally, the masked encoded signal 180 may be transmitted straight to the demodulator 520, which is capable of extracting the modulated carrier signal 160 from the masked encoded signal 180 and demodulating the modulated carrier signal 160 to extract the data signal 130. Once the data signal 130 is isolated, the data signal 130 is passed to a decoder 530 to decode the data signal 130 to extract the data 110. For example, if a pulse-duration modulation (PDM) scheme was utilized for modulating the carrier signal with the data signal, the

detection of the pulses representing the data 110 (e.g., the dot, dash, and pause sequences in Morse code) may be decoded by comparing the energy ratios of the signals in the carrier signal 160 with the energy in the masking signal 170. A threshold ratio level may be set (e.g., at greater than 0.5) to determine when a pulse is “on”, thereby determining the pulse sequence.

- 5 Based on the encoding algorithm utilized, the entire pulse sequence may be converted/translated into data useable by the decoding device.

Another embodiment of the present invention includes the use of the enhanced acoustic transmission signal 100 to be broadcast over open space, as in a room or outdoor area using a speaker, such as a public announcement (PA) system. Therefore, in addition to the audio transmitted over the air to listeners in the audible area, a masked encoded signal 180 is transmitted therewith, and, any decoding receiver device within the audible area may be adapted to receive the masked encoded signal 180 transmitted with the audio and extract any data transmitted therewith. For example, a receiver device having a microphone, remotely located from the speaker, may pick up the audio as well as the masked encoded signal 180 broadcast from the speaker. And, the receiver device may be adapted to extract any data 110 within the masked encoded signal 180.

Furthermore, the receiver device may be embodied within a portable device, such as a cellular telephone, personal digital assistant (PDA, like a Palm computer), a laptop computer, or any other similar device. For example, if a user is at an airport terminal with a portable receiver device adapted to decode a masked encoded signal 180, and flight information is announced over the PA system, the portable receiver device, when properly configured, may receive the masked encoded signal 180 containing the flight information transmitted along with the audio

announcement so that the user may review the data displayed on the portable receiver device, especially if the user did not hear all of the information announced over the PA speakers.

Additionally, the masked encoded signal 180 may contain data to be used as a “watermark” in order to authenticate and/or identify audio broadcasts. For example, serial number/identifying information or other information, which may be encrypted, may be transmitted in the masked encoded signal 180 along with the audio broadcast sent over the air through a speaker. The audio broadcast may then be identified, using a receiving device to extract the watermark information from the masked encoded signal 180 transmitted with the audio broadcast. As with any of the “open air” masked encoded signal 180 audio broadcasts using a speaker, the receiving device is adapted to overcome additional error-creating variables present in open air situations, such as outside noise, and requires a more robust system than that used in, for example, a telephony application.

While the description above refers to particular embodiments of the present invention, it will be understood that many modifications may be made without departing from the spirit thereof. The accompanying claims are intended to cover such modifications as would fall within the true scope and spirit of the present invention. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims, rather than the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT IS CLAIMED IS:

- 1 1. A method of generating an enhanced acoustic transmission signal, the method
2 comprising:
3 generating a carrier signal;
4 receiving data and generating a data signal representing the data;
5 modulating the carrier signal with the data signal to form a modulated carrier
6 signal at a carrier frequency;
7 generating a masking signal to mask the modulated carrier signal from being
8 audible by a human ear;
9 receiving audio and generating an audio signal based on the audio, wherein a
10 frequency band surrounding the carrier frequency is removed from the audio signal; and
11 combining the modulated carrier signal, the masking signal, and the audio signal
12 to form the enhanced acoustic transmission signal.
- 1 2. The method according to claim 1, wherein the carrier signal is a sine wave.
- 1 3. The method according to claim 2, wherein the modulated carrier signal is a pulsed
2 sine wave.
- 1 4. The method according to claim 1, wherein the masking signal is narrowband
2 random noise.

1 5. The system according to claim 1, wherein the modulated carrier signal is at a level
2 that is detectable by a decoding system while still being masked by the masking signal.

1 6. The system according to claim 1, wherein the masking signal has a bandwidth less
2 than one critical band of the modulated carrier signal.

1 7. A method of decoding an enhanced acoustic transmission signal including a
2 modulated carrier signal formed by modulating a carrier signal at a carrier frequency with a data
3 signal representing data, a masking signal adapted to mask the modulated carrier signal from
4 being audible by a human ear, and an audio signal modified so that a frequency band
5 surrounding the carrier frequency is removed from the audio signal, the method comprising:
6 receiving the enhanced acoustic transmission signal;
7 filtering the enhanced acoustic transmission signal to isolate the modulated carrier
8 signal from the masking signal and the audio signal of the enhanced acoustic
9 transmission signal;
10 demodulating the modulated carrier signal to extract the data signal from the
11 modulated carrier signal; and
12 decoding the data signal to extract the data.

1 8. The method according to claim 7, wherein the modulated carrier signal is isolated
2 from the masking signal by using a finite impulse response (FIR) filter.

1 9. A system to generate an enhanced acoustic transmission signal, the system
2 comprising:
3 a carrier signal generator to generate a carrier signal;
4 a data signal generator to receive data and to generate a data signal representing
5 the data;
6 a signal modulator to modulate the carrier signal with the data signal to form a
7 modulated carrier signal at a carrier frequency;
8 a masking signal generator to generate a masking signal to mask the modulated
9 carrier signal from being audible by a human ear;
10 an audio input device to receive audio and to generate an audio signal based on
11 the audio, wherein a frequency band surrounding the carrier frequency is removed from
12 the audio signal; and
13 a signal adder to combine the modulated carrier signal, the masking signal, and
14 the audio signal to form the enhanced acoustic transmission signal.

1 10. The system according to claim 9, wherein the carrier signal generator is a sine
2 wave generator that generates a sine wave.

1 11. The system according to claim 10, wherein the modulated carrier signal is a
2 pulsed sine wave.

1 12. The system according to claim 9, wherein the masking signal generator is a
2 narrowband random noise generator to generate narrowband random noise.

6 a receiver to receive the enhanced acoustic transmission signal;
7 a filter to filter the enhanced acoustic transmission signal to isolate the modulated
8 carrier signal from the masking signal and the audio signal of the enhanced acoustic
9 transmission signal;
10 a demodulator to demodulate the modulated carrier signal to extract the data
11 signal from the modulated carrier signal; and
12 a decoder to decode the data signal to extract the data.

1 19. The system according to claim 18, wherein the modulated carrier signal is isolated
2 from the masking signal by using a finite impulse response (FIR) filter.

1 20. The system according to claim 18, wherein the system is a telephone system
2 having a speaker to produce audio from the audio signal, and a display to show the data extracted
3 from the modulated carrier signal.

1 21. A system to generate and receive an enhanced acoustic transmission signal, the
2 system comprising:
3 a carrier signal generator to generate a carrier signal;
4 a data signal generator to receive data and to generate a data signal representing
5 the data;
6 a signal modulator to modulate the carrier signal with the data signal to form a
7 modulated carrier signal at a carrier frequency;

8 a masking signal generator to generate a masking signal to mask the modulated
9 carrier signal from being audible by a human ear;

10 an audio input device to receive audio and to generate an audio signal based on
11 the audio, wherein a frequency band surrounding the carrier frequency is removed from
12 the audio signal;

13 a signal adder to combine the modulated carrier signal, the masking signal, and
14 the audio signal to form the enhanced acoustic transmission signal;

15 a communication channel to receive and transmit the enhanced acoustic
16 transmission signal;

17 a receiver to receive the enhanced acoustic transmission signal from the
18 communication channel;

19 a filter to filter the enhanced acoustic transmission signal to isolate the modulated
20 carrier signal from the masking signal and the audio signal of the enhanced acoustic
21 transmission signal;

22 a demodulator to demodulate the modulated carrier signal to extract the data
23 signal from the modulated carrier signal; and

24 a decoder to decode the data signal to extract the data.

1 22. The system according to claim 21, wherein the modulated carrier signal and the
2 masking signal are first combined to form a masked encoded signal, then the audio signal is
3 combined with the masked encoded signal to form the enhanced acoustic transmission signal.

1 23. The system according to claim 21, wherein the modulated carrier signal, the
2 masking signal, and the audio signal are combined simultaneously to form the enhanced acoustic
3 transmission signal.

1 24. The system according to claim 21, wherein the modulated carrier signal is isolated
2 from the masking signal by using a finite impulse response (FIR) filter.

1 25. A method of generating and receiving an enhanced acoustic transmission signal,
2 the method comprising:

3 generating a carrier signal;
4 receiving data and generating a data signal representing the data;
5 modulating the carrier signal with the data signal to form a modulated carrier
6 signal at a carrier frequency;

7 generating a masking signal to mask the modulated carrier signal from being
8 audible by a human ear;

9 receiving audio and generating an audio signal based on the audio, wherein a
10 frequency band surrounding the carrier frequency is removed from the audio signal;

11 combining the modulated carrier signal, the masking signal, and the audio signal
12 to form the enhanced acoustic transmission signal;

13 transmitting the enhanced acoustic transmission signal over a communication
14 channel;

15 receiving the enhanced acoustic transmission signal from the communication
16 channel;

17 filtering the enhanced acoustic transmission signal to isolate the modulated carrier
18 signal from the masking signal and the audio signal of the enhanced acoustic
19 transmission signal;
20 demodulating the modulated carrier signal to extract the data signal from the
21 modulated carrier signal; and
22 decoding the data signal to extract the data.

1 26. The method according to claim 25, wherein the carrier signal is a sine wave.

1 27. The method according to claim 26, wherein the modulated carrier signal is a
2 pulsed sine wave.

1 28. The method according to claim 25, wherein the masking signal is narrowband
2 random noise.

1 29. The method according to claim 25, wherein the modulated carrier signal is
2 isolated from the masking signal by using a finite impulse response (FIR) filter.

ABSTRACT OF THE DISCLOSURE

A system to generate an enhanced acoustic transmission signal includes a carrier signal generator to generate a carrier signal. A data signal generator is provided to receive data and to generate a data signal representing the data. A signal modulator is also provided to modulate the carrier signal with the data signal to form a modulated carrier signal at a carrier frequency. The system includes a masking signal generator to generate a masking signal to mask the modulated carrier signal from being audible by a human ear. An audio input device is provided to receive audio and to generate an audio signal based on the audio, wherein a frequency band surrounding the carrier frequency is removed from the audio signal. A signal adder is also provided to combine the modulated carrier signal, the masking signal, and the audio signal to form the enhanced acoustic transmission signal.

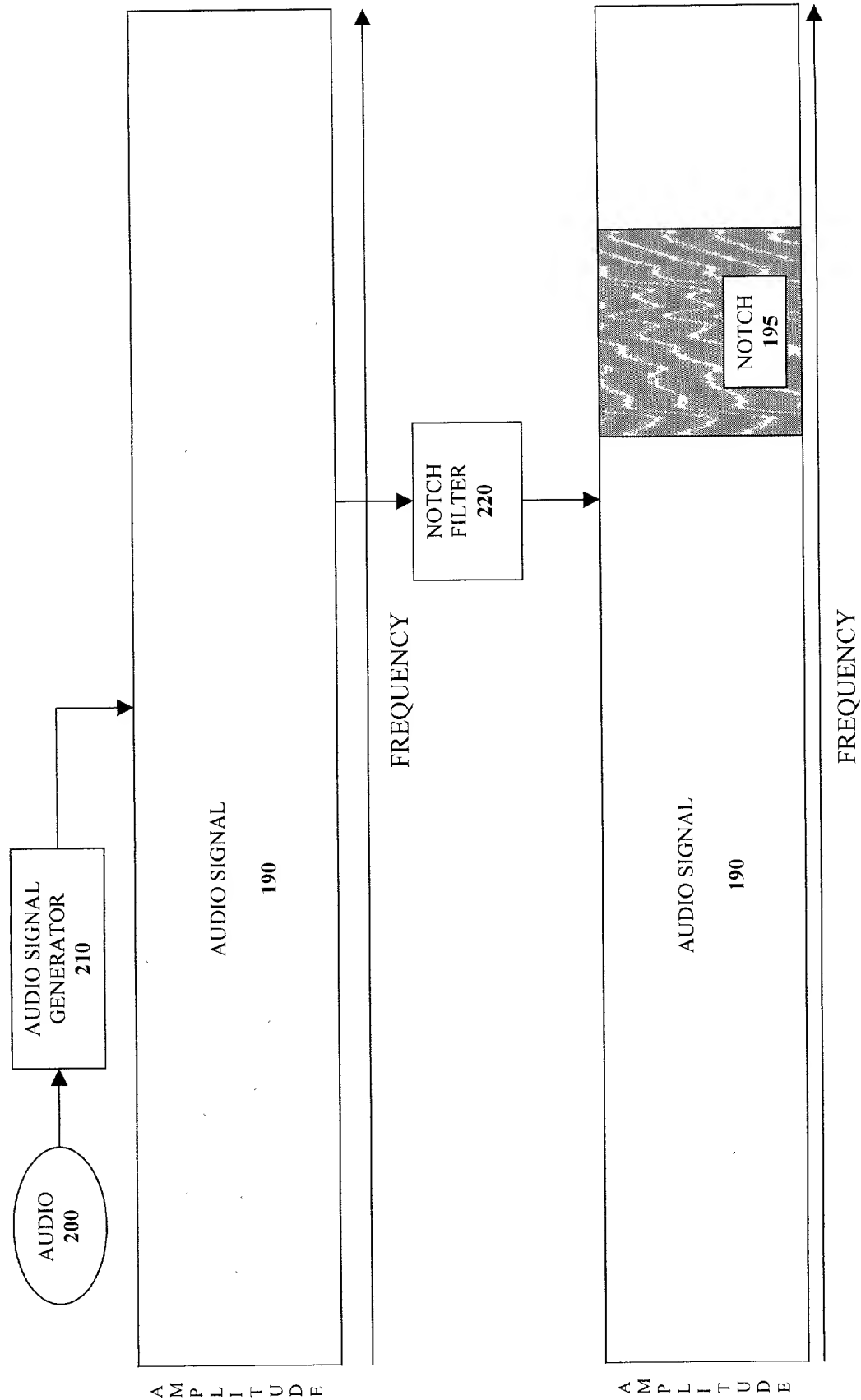


FIG. 2

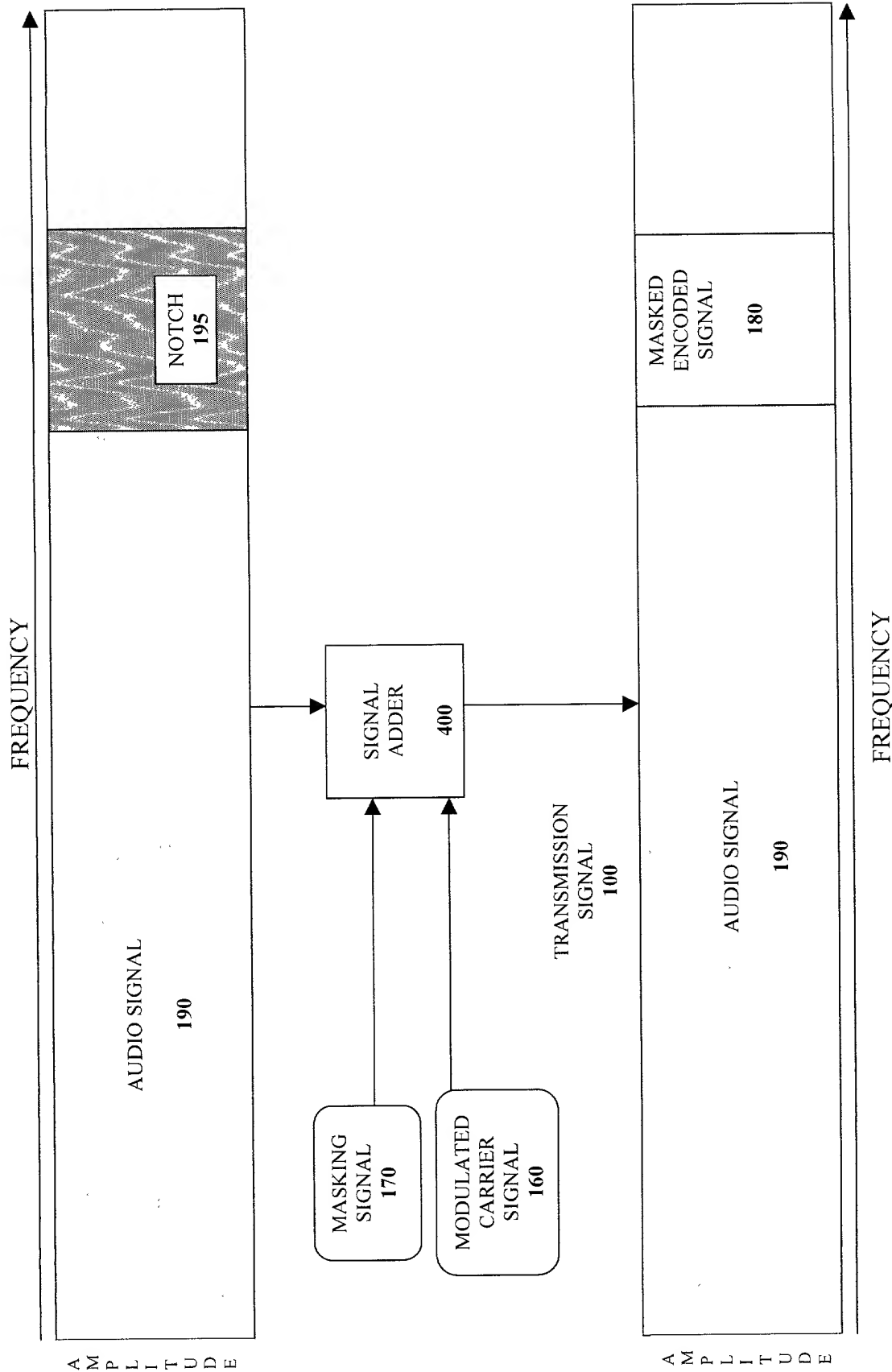
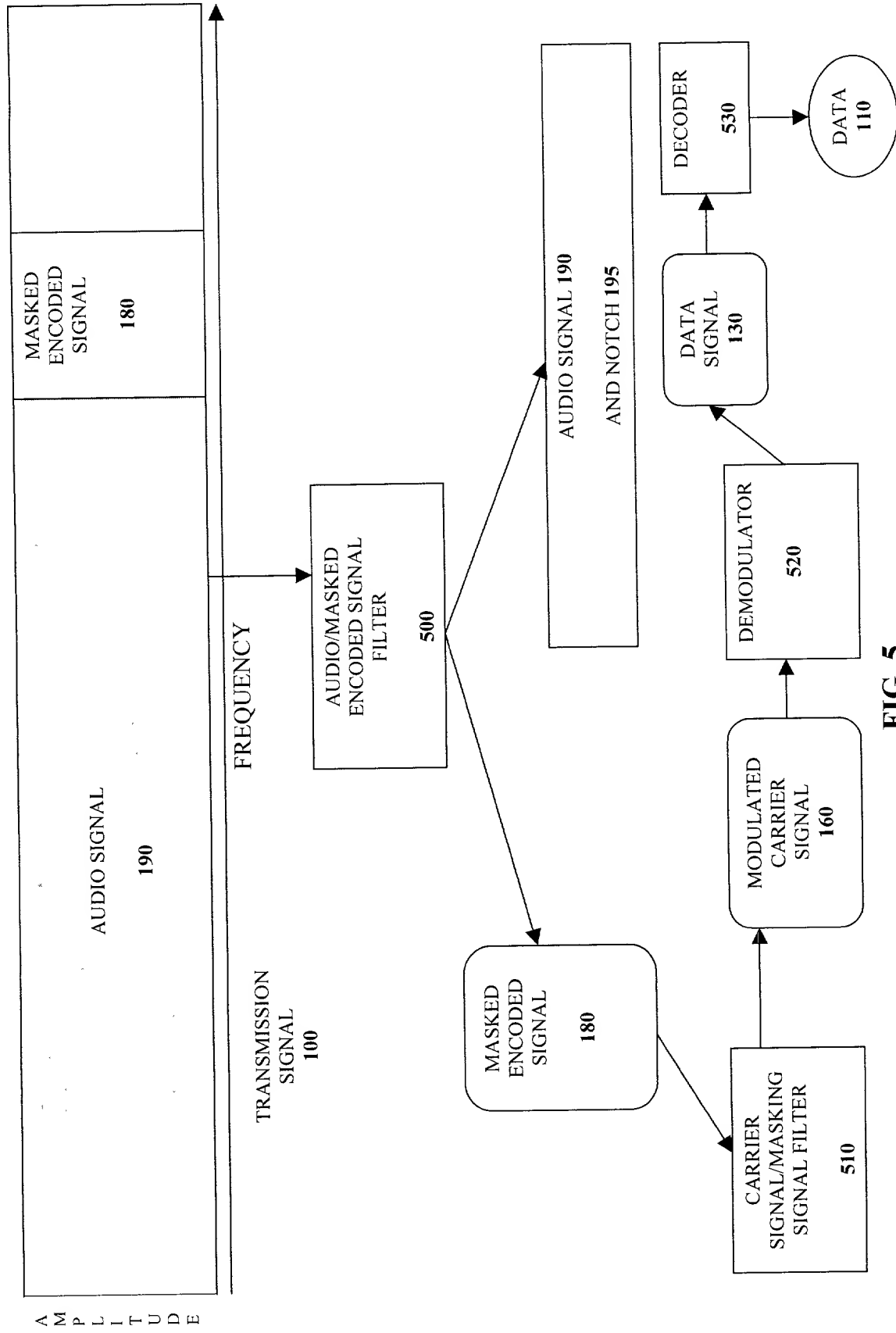


FIG. 4



FOR UTILITY/DESIGN
CIP/PCT NATIONAL/PLANT
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DECLARATIONS

RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PM & S
FORM

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the INVENTION ENTITLED ENHANCED ACOUSTIC TRANSMISSION SYSTEM AND METHOD

The specification of which (CHECK applicable BOX(ES))

X → A ☒ is attached hereto.
BOX(ES) → B. ☐ was filed on _____ as U.S. Application No. _____ /
→ C. ☐ was filed as PCT International Application No. PCT/ _____ / _____ on _____

and (if applicable to U.S. or PCT application) was amended on _____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56. Except as noted below, I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International Application which designated at least one other country than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT International Application, filed by me or my assignee disclosing the subject matter claimed in this application and having a filing date (1) before that of the application on which priority is claimed, or (2) if no priority claimed, before the filing date of this application:

PRIOR FOREIGN APPLICATION(S) Number	Country	Day/MONTH/Year Filed	Date first Laid- open or Published	Date Patented or Granted	Priority NOT Claimed
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If more prior foreign applications, X box at bottom and continue on attached page.

Except as noted below, I hereby claim domestic priority benefit under 35 U.S.C. 119(e) or 120 and/or 365(c) of the indicated United States applications listed below and PCT international applications listed above or below and, if this is a continuation-in-part (CIP) application, insofar as the subject matter disclosed and claimed in this application is in addition to that disclosed in such prior applications, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in 37 C.F.R. 1.56 which became available between the filing date of each such prior application and the national or PCT international filing date of this application

PRIOR U.S. PROVISIONAL, NONPROVISIONAL AND/OR PCT APPLICATION(S) Application No. (series code/serial no.)	Day/MONTH/Year Filed	Status pending, abandoned, patented	Priority NOT Claimed
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

And I hereby appoint Pillsbury Madison & Sutro LLP, Intellectual Property Group, 1100 New York Avenue, N.W., Ninth Floor, East Tower, Washington, D.C. 20005-3918, telephone number (202) 861-3000 (to whom all communications are to be directed), and the below-named persons (of the same address) individually and collectively my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent, and I hereby authorize them to delete names/numbers below of persons no longer with their firm and to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct the above firm and/or a below attorney in writing to the contrary.

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Raymond F. Lippitt	17519	Paul E. White, Jr.	32011	Stephen C. Glazier	31361	Jack S. Barufka	37087
G. Lloyd Knight	17698	Glenn J. Perry	28458	Paul F. McQuade	31542	Adam R. Hess	41835
Carl G. Love	18781	Kendrew H. Colton	30368	Ruth N. Morduch	31044	William P. Atkins	38821
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Alan K. Aldous	31905	Robert D. Anderson	33826	Joseph R. Bond	36458	Richard C. Calderwood	35468
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Charles K. Young	39435	Thomas Raleigh Lane	42781	Calvin E. Wells	43256	Eric S. Chen	43542

(1) INVENTOR'S SIGNATURE: David L. Graumann Date: 6/20/00

David	L.	GRAUMANN	
First	Middle Initial	Family Name	
Residence	Beaverton	Oregon	USA
City	State/Foreign Country	Country of Citizenship	
Post Office Address	16756 SW Sarala Street		
(include Zip Code)	97007		

(2) INVENTOR'S SIGNATURE: _____ Date: _____

First	Middle Initial	Family Name	
Residence	City	State/Foreign Country	Country of Citizenship
Post Office Address	City	State/Foreign Country	Country of Citizenship
(include Zip Code)			

FOR ADDITIONAL INVENTORS, "X" box ☐ and proceed on the attached page to list each additional inventor.
☐ See additional foreign priorities on attached page (incorporated herein by reference).

Atty. Dkt. No. PM81674-265759
(M#)

Rule 56(a) & (b) = 37 C.F.R. 1.56(a) & (b)
PATENT AND TRADEMARK CASES - RULES OF PRACTICE
DUTY OF DISCLOSURE

- (a) ...Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the [Patent and Trademark] Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability...(b) information is material to patentability when it is not cumulative and (1) It also establishes by itself, or in combination with other information, a prima facie case of unpatentability of a claim or (2) refutes, or is inconsistent with, a position the applicant takes in: (i) Opposing an argument of unpatentability relied on by the Office, or (ii) Asserting an argument of patentability

PATENT LAWS 35 U.S.C.

§102. Conditions for patentability; novelty and loss of right to patent

A person shall be entitled to a patent unless--

- (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent or
- (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States, or
- (c) he has abandoned the invention, or
- (d) the invention was first patented or caused to be patented, or was the subject of an inventor's certificate, by the applicant or his legal representatives or assigns in a foreign country prior to the date of the application for patent in this country on an application for patent or inventor's certificate filed more than twelve months* before the filing of the application in the United States, or
- (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent, or
- (f) he did not himself invent the subject matter sought to be patented, or
- (g) before the applicant's invention thereof the invention was made in this country by another who had not abandoned, suppressed, or concealed it. In determining priority of invention there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other.

§103. Condition for patentability; non-obvious subject matter

- (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made. . . .
- (c) Subject matter developed by another person, which qualified as prior art only under subsection (f) or (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

* Six months for Design Applications (35 U.S.C. 172).